3

OBSERVATIONS AND NOTES

ON THE

ARTERIES OF THE LIMBS.

BY

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PREFACE TO THE FIRST EDITION.

Many of the data employed by the Author in support of his views have been taken from Mr. Quain's noble work on the Arteries; of this he wishes to make the fullest acknowledgment.

Mr. Quain's observations have been appealed to—firstly, as being more complete than any the author could himself produce; and, secondly, as offering independent evidence on the subject discussed. It is hoped that the views advanced may serve to indicate a method of simplifying the details of descriptive anatomy, and may suggest points for further physiological investigation.

8 Stratford Place, W.,

July, 1858.

PREFACE TO THE SECOND EDITION.

The Author, in the Preface to the First Edition, had to acknowledge with pleasure how greatly he was indebted to Mr. Quain for facts and data. In this present Preface he wishes to renew that acknowledgment; and he has further to say that he is under great obligation to his colleague, Dr. Burdon Sanderson, who has kindly furnished him with an important note on the physiological considerations involved.

In reprinting, wood-cuts have been substituted for the lithographic plate; the cuts are simply diagramatic, and are not intended to bear artistic criticism.

8 Stratford Place, W.,

November, 1864.

OBSERVATIONS AND NOTES

ON THE

ARTERIES OF THE LIMBS.

THE arteries of the limbs have hitherto received consideration in respect only of their anatomical details; the purpose of the following pages is to shew, from the analysis of facts already ascertained, that the arteries of limbs admit of a classification based on essential differences; that their distribution is homologous, or in accordance with a general plan; that the so-called irregularities, or varieties of distribution, have a definite relation to this general plan; and lastly, to suggest some further explanation of certain of the observed phenomena of the circulation.

If the trunks which result from the bifurcation of the common iliac artery be compared, the comparison being limited to the pelvic portions of these vessels, it will be seen that the one artery is in many respects the converse of the other; thus the external iliac is nearly straight, continuing the direction of the parent trunk, and gives off no branches until near its termination; while the internal iliac takes a turn downwards, nearly at right angles to the parent trunk, and after a very short course divides and subdivides into many branches.

The essentially same description applies to the trunks resulting from the bifurcation of the com-

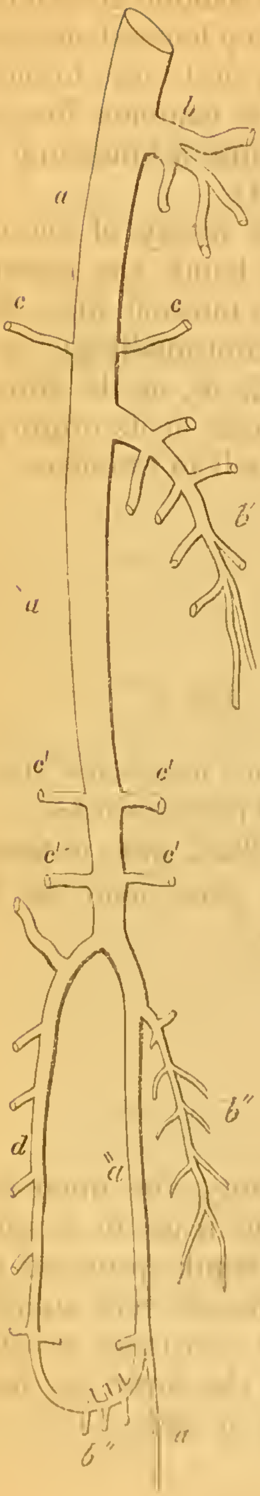

FIG. 1.

Diagram of the plan of the arteries of the lower limb.

a, External iliac.

b, Internal iliac resulting from the bifurcation of the common iliac.

a', The superficial femoral.

b', The deep femoral resulting from the bifurcation of the common femoral.

a'', The posterior tibial.

b'', The peroneal resulting from the bifurcation of the tibio-peroneal trunk.

a''', The internal plantar.

b''', The external plantar resulting from the bifurcation of the posterior tibial.

c c, The circumflex ilii and deep epigastric.

c' c' c' c', The articular arteries of the popliteal.

d, The anterior tibial.

mon femoral artery. The superficial femoral gives off but few and small branches, whilst the deep femoral, at a short distance from its origin, gives many and large branches.

It may be said, therefore, of the common iliac and common femoral, that each divides into a branching and a non-branching trunk. (See Fig. 1).

If we still follow downwards the artery of the inferior extremity to the tibio-peroneal trunk, the peroneal, (Fig. 1) *b''*, is seen to resemble the internal iliac, *b*, or the profunda, *b'*, in respect of its continually giving off branches; whilst the posterior tibial, *a''*, at the internal malleolus, has nearly the same calibre as at its origin; or, in other words, has not expended itself in branches.

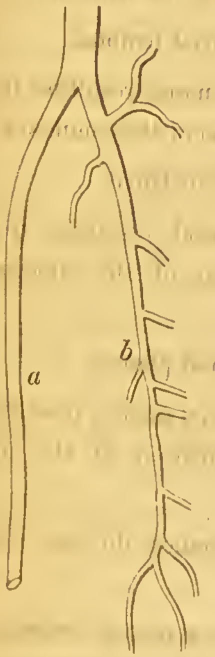

Fig. 2.

Drawing from a dissection of the posterior tibial and peroneal arteries.

a, Posterior tibial, giving no branch.

b, Peroneal, giving many and large branches.

On turning to the upper extremity, the ulnar-interosseous artery will be found to bifurcate in a similar manner; the common interosseous trunk springing from the parent trunk at right angles, gives off very numerous branches, whilst the ulnar proper continues nearly of the same size, being as large at the lower as in the upper part of its course. (See Fig. 5, page 17.)

The division of the main trunk of an artery into two (or more) others, branching and non-branching, is found, therefore, to occur in other arteries besides the iliac and femoral.

An examination of the ultimate distribution of these branching and non-branching trunks respectively (the anatomical features of which are so contrary), demonstrates that each of the branching trunks is distributed to that segment of the limb in which it is found, while the non-branching trunk transmits the blood to the distal segment or segments.

Thus we have two classes of vessels, one comprising the trunks distributed to the segments in which they are found—which, in fact, pertain to the segments; and another comprising trunks transmissive to distal segments. The former may be denominated segmental; the latter, transegmental.

If we look a little more minutely, we shall be struck with the fact that certain vessels springing from different points run towards, and open into, one another, or anastomose; and also if we again turn to the arteries of the leg, and examine the anterior tibial (Fig. 1, *d*), we shall see that this vessel is maintained as a definite trunk from the upper to the lower end of the leg; that it gives off no large single branch, much less does it bifurcate; but it gives very numerous small branches, and bodily joins, so to speak, the plantar arch by dipping between the great toe and the toe next to it.

There are, thus, two other kinds of vessels to be considered, namely, the anastomotic, which cannot be included in either class already named, and the composite, multifarious in function, possessing in a greater or less degree the characteristics of all.

For classification three primary classes and a composite class appear, then, to be required as follows:—

I. Segmental. III. Anastomotic or Communicating.
II. Transegmental. IV. Composite.

The characteristics of each of these classes may be more fully detailed.

The segmental arteries, distributive in their function, branch either by large offshoots, which again subdivide, or by numerous small twigs at right angles, or nearly so, to the parent vessel. They continually diminish in size as they course towards their termination, the rapidity of diminution being proportionate to the size and number of the branches given off. They lie generally in close proximity to the bone or bones of the segment to which they belong, and supply the nutrient vessels of those bones. They terminate by anastomosing with other arteries.

The transegmental arteries continue the line of direction of the parent trunk, do not diminish in size during the greater part of their course, giving few and small branches, excepting at their commencement or near their termination.

The anastomotic arteries have no special direction; they are connected with the vessels which they unite at right, or obtuse, or acute angles; they run towards or away from the centre of circulation; they may be single or double, or, dividing, may re-unite and form a plexus. They join (*a*) segmental arteries with each other; (*b*) segmental with transegmental; (*c*) transegmental with each other; (*d*) different portions of the same trunk.

The composite class of arteries is described by its name, but in individuals of this class the characteristics of any one of the other classes may predominate so as partially to mask their true nature.

It is necessary to cite examples of these two latter classes in order to render clear what is intended to be described. Representatives of the anastomotic class may be seen at the elbow and knee-joints, between the profunda arteries and the recurrents in the first, and between the superior and inferior articular arteries in the second instance.

The anterior tibial (Fig. 1, *d*) presents an example of a composite artery. It supplies by numerous branches the muscles of the anterior region of the leg; it transmits to the foot, and by the most direct anastomosis to be found in either extremity, joins the termination of the internal plantar; it is, therefore, at once, partly segmental, transegmental, and anastomotic.

So much, for the present, regarding the basis of the proposed classification. We will now proceed to consider the homologous nature of the distribution of arteries, and the relation of varieties to type. For this purpose let us compare the artery of the thigh with the artery of the upper arm—the common femoral with the axillary-brachial artery. At first sight there appears to be but little resemblance. The common femoral, as already stated, divides into a branching and non-branching trunk; but the axillary-brachial, on the contrary, gives off branches at various points along its course.

But, this remarkable circumstance demands consideration—namely, that the axillary-brachial artery shews a tendency to assume the arrangement normal to the femoral, whilst the femoral itself very seldom varies essentially in its mode of arrangement.

On appealing to extended observation, it will be found that the chief branches of the brachial—namely, the superior and inferior profunda arteries—are very frequently given off by a common trunk; or, as it happens still more frequently, by a trunk common to them and to the posterior circumflex, or to some other branch pertaining to the axillary region.

Mr. Quain has recorded* the disposition of the branches of the brachial artery in 478 examples; in 115 of these the superior and inferior profunda arose either by a common trunk, or by a trunk common to

* *Anatomy of the Arteries*, p. 235, *et seq.*

them and to others. Thus a clubbing, to a greater or less degree, of the branches of the axillary-brachial, or brachial only, has been observed in about *one case in four*, according to Mr. Quain's tables.

On the other hand, Mr. Quain says* of the femoral artery—

"Exclusively of the variations that occur in the place at which it gives rise to the 'deep femoral,' and the occasional origin from it of branches usually derived from another source (circumstances to be afterwards noticed), the deviations from the ordinary disposition observed in the main artery are exceedingly rare and few in kind. In this respect this artery contrasts strongly with that of the upper limb. The latter has been seen to divide very frequently above the ordinary position, (in the axilla or in the upper arm), while the femoral artery, on the contrary, is so little liable to change of this kind, that I have not hitherto met with an example." (See note and Fig. 3.) In order to give this quotation the weight to which it is entitled, it is necessary to quote further, as follows :† "The position the origin of this artery bears in the thigh, or its height, is a subject of much practical importance. . . . With the view of ascertaining the point with some degree of accuracy, the distance between the place of origin and the lower margin of Poupart's ligament (which was taken as the line of demarcation between the iliac and the femoral parts of the arterial trunk) was measured in several cases. The details of this examination are contained in the Table (page 475 et seq.), and the following is an abstract of it. Entire number noted in the Table, 431.

"The deep femoral arose—

Above Poupart's ligament . . .	1
Under that structure	7
Below it, $\frac{1}{2}$ inch and less . . .	13

* Op. cit., p. 513. † Op. cit., p. 520.

More than ½ and not exceeding 1 inch, *those measuring* 1 *inch being* 65 *of the number* . . .	86
More than 1, not exceeding 1½ .	183
More than 1½, not exceeding 2 .	109
More than 2, not exceeding 2½ .	19
More than 2, not exceeding 3 . .	12
Four inches	1."

Thus, according to the independent testimony of Mr Quain, the profunda took origin in 398 out of 431 cases, from an extent of vessel not exceeding two inches in length, a variation quite insignificant from the point of view from which the arrangement of the artery is being here contemplated.

And Mr. Quain adds, "Turning attention in the next place to the artery in the opposite direction, it will be found that the branches have little tendency to encroach upon the superficial femoral."*

I have here (Fig. 3) appended a diagram of a very unusual variety met with by myself, as a remarkable instance of exception to this general rule.

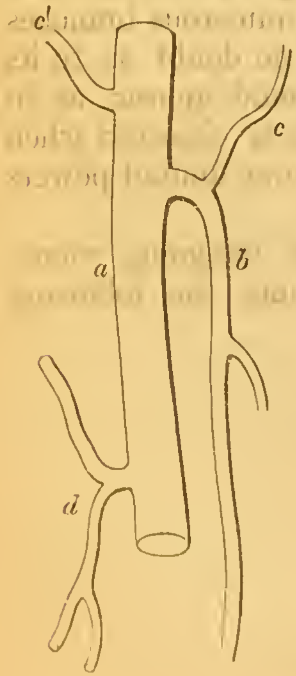

FIG. 3.

Diagram from dissection of a very unusual example of variety in the femoral:—*a*, Superficial femoral; *b*, Profunda, which gives off *c*, the deep epigastric; the circumflex ilii, *c'*, being given from the external iliac; the external circumflex, *d*, is from the superficial femoral at a considerable distance from its origin.

* Op. cit., p. 521.

Now, since the plan of distribution of the common femoral, Fig. 1, *a′*, *b′*, or of the tibio-peroneal, Fig. 1, *a″*, *b″*, or of the ulnar-interosseous, Fig. 5, *a*, *b*, is clearly analogous to that of the common iliac; and since *the axillary-brachial, as just proved, so frequently presents some approach to that mode of distribution;* the conclusion, that the plan of the common iliac is the general one, and presents the typical arrangement—namely, a bifurcation into a branching vessel for the nutrition of the proximal segment of the limb, and a non-branching uniform vessel for transmission to the distal segments, seems inevitable.

Further, when the terminal segment is reached, the division of the main trunk still takes place, as is seen in the case of the posterior tibial, bifurcating, as it does, at the ankle into the internal and external plantar arteries; the striking inequality in the proportions of these two vessels at once suggests the idea of the irregular and diminutive internal plantar being an *abortive* transegmental artery, the large size and numerous branches of the external plantar allowing of no doubt as to its segmental character; and thus, it would appear, as in the construction of the skeleton, type is observed when the purpose is no longer obvious to our limited powers of understanding.

Assorted in accordance with the foregoing views, the arteries of the lower limb fall into the following order:

Arteries of the segmental class—
Internal iliac.
Deep femoral.
Peroneal.*
External plantar.

* See Fig. 2, *b*, and Fig. 4.

FIG. 4.

Drawing from dissection:—
a, Posterior tibial, cut.
b, Peroneal, giving a large branch which is seen to subdivide into two others, respectively distributed to the *m. peroneus longus* and *m.p. brevis*. The peroneal supplied thus the outer, as well as the posterior region of the leg.

Arteries of the transegmental class—

External iliac, with the common femoral.
Superficial femoral, with the popliteal.
Posterior tibial.*
Internal plantar (abortive).

Arteries of the anastomotic class—certain branches of—

Ilio-lumbar.
Gluteal.
Sciatic.
Obturator.
Deep epigastric.
Deep circumflex iliac.
Deep femoral.
Anastomotic of superficial femoral.
Popliteal, *i. e.*, the plexus about the knee-joint.
Recurrent of { Anterior tibial. / Posterior tibial.
Malleolar of { Ant. tibial. / Post. tibial and Terminal of peroneal.

Artery of the composite class—

Anterior tibial.

* I have a drawing of the posterior tibial and peroneal arteries, from a dissection by Mr. C. P. Langford, formerly a student of the Middlesex Hospital. The posterior tibial in this example gave off one small twig only; whilst the peroneal expended itself in fourteen branches; being nearly the counterpart of the specimen dissected by myself, and shewn at Fig 2.

There is an evident difficulty in disentangling the arteries of the anastomotic class, since they scarcely exist purely as such, but distribute muscular or nutrient branches in their course; some in the above list are obviously more essentially anastomotic than others—for example, the obturator artery: this vessel in the preparation of the case of ligature of the external iliac, contained in Guy's Hospital Museum, I have observed, *equals in size the external carotid at the angle of the jaw.* One may, therefore, infer that its share in establishing the collateral circulation was considerable.

Sir Astley Cooper says in his "Account of the Anastomosis of the Arteries of the Groin:"*

"The principal agents, then, of the new circulation, are the gluteal artery, with the external circumflex; the obturator, with the internal circumflex; and the ischiatic, with the arteria profunda; and the obturator artery is supplied with blood principally by the internal pudendal, when the obturator arises from the epigastric."

Sir A. Cooper has also described the anastomosing arteries which, in a case of ligature of the femoral, transmitted the blood to the parts below the ligature, as follows:—

"The first artery sent off passed down close to the back of the thigh-bone, and entered the two superior articular branches of the popliteal artery.

"The second new large vessel arising from the profunda at the same part with the former, passed down by the inner side of the biceps muscle to an artery of the popliteal, which was distributed to the gastrocnemius muscle; whilst a third artery, dividing into several branches, passed down with the sciatic nerve behind the knee-joint, and some of the branches united themselves with the inferior articular arteries of the

* *Med.-Chir. Trans.*, vol. iv., p. 431.

popliteal, with some recurrent branches of those arteries, with arteries passing to the gastro-cnemii; and lastly, with the origin of the anterior and posterior tibial arteries."*

In Bartholomew's Hospital Museum there is a preparation of a limb in which the femoral had been tied *eleven years* before death (Preparation, F. 3). In this specimen it may be seen that collateral circulation has been effected by the anastomosis of branches of the profunda and sciatic with the articular arteries.

In the Museum of the Royal College of Surgeons, there is a similar preparation (of John Hunter's) presenting analogous appearances.

Liston has given a drawing of the collateral circulation, illustrating the same facts.

To what do the sural branches of the popliteal artery correspond? Probably to the twigs from the recurrents of the ulnar and radial arteries given to the muscles of the superficial layers of the forearm: but the sural being derived from the main channel.

In attempting to classify the arteries of the upper extremity, we meet with a difficulty at the outset. The relation of the artery to the limb being complicated by the demand made through the vertebral and inferior thyroid arteries, respectively by the nervous centre, and thyroid body.

Then, again, the axillary-brachial artery presents an exception to type, the branches being separately given off. Below the elbow, however, we meet with the division into distinct segmental and transegmental trunks. (Fig. 5.) Approximately arranged, the arteries of the upper extremity stand thus:—

Arteries of the segmental class—

Thyroid axis.

Thoracic axis, or acromial thoracic.

* *Med. Chir. Trans.*, vol. ii., p. 254. "Dissection of a limb on which the operation for popliteal aneurism had been performed."

Subscapular.
Posterior circumflex.
Superior and inferior profunda.
Interosseous trunk.
Palmar arches.

Arteries of the transegmental class—
Second and third portions of the subclavian.
Part of axillary below the thoracic axis.
Brachial below the origin of inferior profunda.
Radial.
Ulnar Proper, *i.e.*, after the origin of the interosseous trunk.
Superficial volar (abortive).

Arteries of the anastomotic class—
Internal mammary.
Branches of the transverse cervical and transverse humeral.
Branches of the thoracic axis.
,, alar thoracic.
,, long thoracic.
The superior thoracic.

FIG. 5.

The brachial, dividing into radial and ulnar, *a*, *c*, the latter giving the interosseous trunk. The anterior interosseous, *b*, gives usually from fifteen to twenty offsets, which, after supplying muscles of both the deep and superficial layers of the front of the forearm, perforate the interosseous ligament, and help to supply the posterior group.

Plexus formed about the elbow by branches of the superior and inferior profunda, anastomotic, and recurrents of the radial, ulnar, and interosseous.

The terminal branches of the anterior interosseous.

The carpal plexus.

Mr. Aston Key has described the vessels establishing the collateral circulation in a case of ligature of the subclavian. He says :—

"It would be impossible to particularize all the anastomosing vessels which, by a circuitous course, formed a communication between the subclavian artery above the ligature and the axillary trunk below the tumour, and thus assisted in restoring the calibre of the latter to its natural size; but they may be divided into three sets :—

"1. A posterior set, consisting of the supra-scapular and posterior-scapular branches of the subclavian, which anastomosed with the infra-scapular from the axillary.

"2. An internal set, produced by the connexion of the internal mammary on the one hand, with the short and long thoracic arteries and the infra-scapular on the other.

"3. A middle or axillary set, which consisted of a number of small vessels, derived from branches of the subclavian above, and passing through the axilla, to terminate either in the main trunk, or in some of the branches of the axillary below.

"The chief agent in the restoration of the axillary trunk below the tumour was the infra-scapular artery, which communicated most freely with the internal mammary, supra-scapular and posterior scapular branches of the subclavian, from all which it received so great an influx of blood as to dilate it to three times its natural size."*

We can now proceed to review the more important

* *Guy's Hospital Reports*, vol. i., p. 64; 1836.

varieties of distribution, to examine their relation to the type, and to test the classification proposed by the light thus thrown on the subject.

We shall find that in those parts of the arterial system in which the simple typical arrangement obtains, few individual variations in the mode of disposition are to be met with; the opposite being the case in the arteries not so distributed. Thus the common iliac and common femoral, and the primary trunks resulting from their bifurcation, very rarely present any variety of an essential nature. In our present consideration of these vessels, anatomical points of great practical interest to the surgeon have little importance—such, for instance, as their length, and the position of their origin and place of division.

There is one of the secondary branches—namely, the obturator—the disposition of which is so variable that it demands especial notice. It has been shewn that the obturator is an important anastomotic channel, and forms an essential link in the collateral circuit.* The variation in question consists in the transference of this anastomotic branch from the segmental to the transegmental trunk; whereby the anastomosis is established between a segmental and transegmental artery, in place of its being between two segmental arteries.

In 361 instances observed by Mr. Quain,† the obturator was derived from the internal iliac in 247 cases,‡ from the epigastric in 103, equally from the internal iliac and epigastric by two roots in 5, from the external iliac in 6.

A variation of a similar character is met with in the relation of femoral and profunda arteries. It has been observed that when the descending branch of the external

* Page 15. † *Op. Cit.*, p. 447.

‡ A remarkable and very rare variety has been described by Dr. Redfern, in which the epigastric and obturator arose by a common trunk from the internal iliac.

circumflex of the profunda is wanting, the muscular branches from the superficial femoral are unusally large—and as far as my own experience goes, the added branch most frequently springs from *the lower part of the vessel*, opposite the anastomotica. Thus the articular plexus about the knee-joint loses its communication with the external circumflex, an offshoot of the segmental profunda, but gains one with the superficial femoral.

In the artery of the upper extremity we find an analogous condition in the origin of the transversalis colli and humeri arteries from the third portion of subclavian, or in the origin of the latter of the two vessels in common with the internal mammary. The proportion in which the obturator has been observed to arise, either directly or indirectly, from the external iliac, approximates curiously to the proportion in which the posterior scapular artery (transversalis colli) arose independently from the subclavian instead of from the thyroid axis.

According to Mr. Quain's observations just quoted, the obturator arose from the external iliac in 114 out of 361 cases; whilst the posterior scapular arose from the subclavian, beyond the anterior scalene muscle, in 101 out of 298 cases.*

The popliteal artery appears to be little liable to variation. It occasionally divides above, but never below the usual point.

The terminal branches of the popliteal vary considerably as to relative size. The most interesting peculiarity of distribution consists in a tibio-peroneal trunk affording the anterior instead of the posterior tibial; whereby the arrangement is rendered analogous to the normal disposition of the common interosseous trunk in the forearm.† A further resemblance in the arrangement of the peroneal and anterior tibial to that of the interosseous arteries is found in other cases, as for example, where a very small

* *Op. Cit.*, p. 176. † See Fig. 6.

anterior tibial is reinforced by the peroneal at the lower part of its course. It is, however, more common to find the peroneal reinforcing the posterior than the anterior tibial. With regard to the peroneal itself, Mr. Quain observes,* that "Diminution of the size of the peroneal artery is of rare occurrence in comparison with the opposite change." *Thus is indicated a greater tendency on the part of the segmental artery to assume the function of transmission, than on the part of the transegmental to distribute the nutrient branches of the part traversed.*

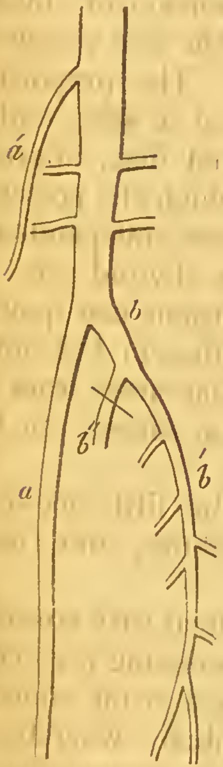

Fig. 6.

Diagram from dissection of a specimen of peroneal and anterior tibial having a common trunk, the arrangement thereby approximating that of the common interosseous trunk of the fore-arm. Thus, taking *a*, the posterior tibial, as representing the ulnar after the giving off of the interosseous trunk, *b*; *a'*, the *anastomotica*, as representing the radial; *b'*, the peroneal, represents the anterior interosseous branch; and *b''*, the anterior tibial, represents the posterior interosseous.

It may be well in this place to make one or two further remarks upon the peroneal and anterior tibial arteries. There can be no doubt of the segmental nature of the peroneal artery—its numerous branches

* *Op. Cit.*, p. 541

and close proximity to the bone sufficiently prove that point, as also that it is the analogue of the anterior interosseous in the fore-arm.

The anterior tibial has, however, been compared to the radial. Cruveilhier says, "the anterior tibial corresponds to the portion of the radial situated in the fore-arm."* Now the position of the anterior tibial much more nearly corresponds with that of the posterior interosseous of the fore-arm. What, then, it may be asked, represents the radial in the leg, and why should the arrangement in the leg differ from that in the fore-arm? In reply to this question, I would observe that the analogue of the radial is probably the *Anastomotica magna* of the femoral; for in monkeys—quadrumanous—the artery, situated similarly to the human *anastomotica*, passes to the foot, the anterior tibial being small, and having a distribution limited to the leg.†

The circumstance that the phalangeal portion of the foot is in man less developed than the corresponding portion of the hand, may also account for the abortive character of the second transegmental trunk in the human leg, and for the transference of its function to a segmental vessel; in other words, for the fusion of the transegmental with the segmental elements, which fusion produces the composite anterior tibial. The increase in size of the peroneal, at the expense of the posterior tibial, is an approach towards a condition similar to that of the anterior tibial—*i.e.*, of a composite artery.

The rudimentary condition of the phalanges in the foot may also explain the absence of a second plantar arterial arch; and this explanation would seem to be more in conformity with the facts than that proposed

* *Descriptive Anatomy*, p. 758.

† Dr. G. M. Humphry compares the anterior tibial with the radial.—*Observations on the Limbs of Vertebrate Animals.* Cambridge. 1860.

by Cruveilhier in the following remarks:—First, "the arteries of the dorsum of the foot are much larger than those on the back of the hand;" and secondly, "the hollow vaulted form of the sole of the foot preserves the plantar arch from compression, to which the palmar arch is liable, in consequence of the flattened form of the hand."

It does not accord with the object of this paper to deal with the subclavian artery, in respect of its variations of distribution, until it becomes properly the artery of the upper extremity. The demands of the nervous system and thyroid body, as before stated (page 16), complicate the relations of the first portion of this vessel. The subclavian, whilst covered by, and after passing the anterior scalene muscle, however, belongs to the upper extremity in the character of a transegmental artery. The most important point to notice is the frequent occurrence of a single anastomotic branch (see page 20), namely, the posterior scapular, "usually" a branch of the thyroid axis (segmental); thus giving an arrangement analogous to the origin of the obturator from the external iliac, as described in the same page. Much less frequently—in but 1 case in $37\frac{1}{2}$—is there a second branch, while a third occurs in but 1 in 131 instances.*

The axillary artery is subject to a variation of arrangement, which approximates its character to that which I have described as typical—that is to say, it bifurcates, and to use Mr. Quain's words, "instead of continuing as an undivided trunk, and giving at intervals offsets to the parts in its neighbourhood, divides into two large branches."

Mr. Quain's table of observations on the axillary arteries contains "a record of 506 cases—270 being of the right side, and 236 of the left. In 51, the

* Quain, *Op. Cit.*, p. 130.

axillary was observed to divide into two such branches, giving a proportion of about 1 in 10."

"In a majority (28) of the cases last referred to, the unusual or second branch was fully equal in thickness to the continued (brachial) trunk, and generally gave origin to the subscapular, both the circumflex and both the profunda branches. So that the peculiarity consisted in the facts of the vessels just named being given from a common origin, in place of arising in succession at greater or less intervals from the axillary and brachial divisions of the main artery."*

In 15 of the remaining 23 examples of "high division," the radial was the branch, in 7 the ulnar, and in 1 the interosseous.†

The brachial artery, dividing above the elbow in 64 cases out of 481,‡ gave off the radial in 45 instances, the ulnar in 12, the interosseous in 3. Thus, from the axillary brachial trunk, the radial was the branch given off in 160 cases, the ulnar in 19, and the interosseous in 4. Hence it would appear that the radial is the *superadded* transegmental trunk.

Another curious circumstance connected with the radial artery, is that when "vasa aberrantia"—long slender vessels arising from the axillary or brachial—exist, they by far the most frequently join the radial (Fig. 7.) The vasa aberrantia, from their constant relation to the radial, are probably the anastomotic element of the superior profunda *displaced to the front.* The radial and ulnar have been met with arising by a common trunk from the axillary, which divided at the elbow joint into these two transegmental vessels, all the segmental branches of the upper and fore-arm having been given off by another common trunk (Fig. 8.)

* *Op. Cit.*, p. 226.

† The remarks made at page 10 render it unnecessary to refer here to the profunda branches of the brachial.

‡ *Op. Cit.*, p. 261.

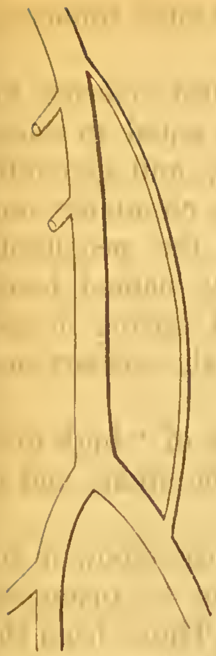

FIG. 7.

Diagram of a vas aberrans.

This very remarkable and rare variety establishes the claim of the ulnar-interosseous artery to be considered as a trunk *common* to the interosseous and ulnar-proper, as, in fact, containing the elements of the segmental and transegmental trunks, and helps to shew that the interosseous artery holds the position of a segmental trunk.

The branch of the radial first requiring notice is the superficial volar, the real nature of which I have ventured to suggest, is that of an *abortive* transegmental trunk. The irregularity of its mode of termination supports this view. 235 observations made on the condition of this artery by Mr. Quain,* gave the following results: in 141 cases, it reached no further than the muscles of the thumb; in 65 it ended in the superficial arch; and in 29 furnished one or more digital branches.

An example of the exaggerated anastomosis of a segmental with a transegmental trunk is offered by the

* *Op. Cit.*, p. 323.

reinforcement of the radial by the interosseous, an anastomosis similar to the reinforcement of the anterior tibial by the peroneal. Cruveilhier says,* "Just as the peroneal often gives origin to the dorsal artery of the foot, so does the interosseous sometimes give off the carpal portion of the radial."

FIG. 8.

Diagram from Fig. 1, Plate 33, Quain's Arteries, shewing a high division of the brachial. One of the branches, *a*, divides at the bend of the elbow into radial and ulnar *a' a'*; the other, *b*, gives "nearly all the branches usually derived from the axillary and the brachial," and "it ends as the interosseous."

The distribution of the ulnar-interosseous trunk requires only one or two remarks. The *median* branch of the anterior interosseous, or the *median artery*, as it has been termed when large, is another example of the exaggeration of a segmental, supplying the deficiency of a transegmental artery. The median artery is not simply the satellite artery of the median nerve, as is usually supposed, but it is the nutrient branch given by the segmental interosseous to the superficial layer of the muscles of the fore-arm. The reinforcing branches,

* *Op. Cit.*, p. 759.

when given from this artery, are probably transferred from the interosseous trunk itself; though on this point I am unable to speak with certainty. I am not acquainted with any other important deviation from the usual disposition, bearing upon the question here discussed.

The various modes of termination of the radial and ulnar in the hand present, as far as I am aware, no essential peculiarities demanding notice in respect of the views now advanced. One circumstance it may be well, nevertheless, to point out, namely, the existence in the hand of two palmar arches coinciding with two pure transegmental trunks, whereas in the foot there is but one plantar arch and one pure transegmental artery.

I have now to revert to certain anastomosing vessels in the upper and lower extremities, which vessels have not hitherto, it appears to me, had their true position assigned to them; these are the so-called articular arteries of the elbow and knee-joints. Scarpa's* beautiful engravings shew how the arteries above the line of flexion join those below—comparatively small branches being sent to the joint itself—how the recurrent from the radial ulnar and posterior interosseous in the arm join with the *profunda* and *anastomotica* arteries, and the recurrent from the anterior and posterior tibial in the leg join with the inferior articular, and these, again, with the superior articular of the poplitcal.

Has not this arrangement some relation to the nature of the movement proper to the joint—to the extreme flexion of which it is capable, and which it so frequently undergoes?

Extreme flexion must impede the current of blood through the main trunk. This is easily proved in the upper extremity, for if the elbow be acutely flexed, the pulse becomes imperceptible at the wrist. When

* See Plates I., III., VI., VII. *Sull' Aneurisma riflessioni ed osservazioni Anatomico-Chirurgiche.*

flexion thus is sudden, unless there existed some diverticular channels, there would arise an injurious strain upon the walls of the main artery.* Moreover, from the

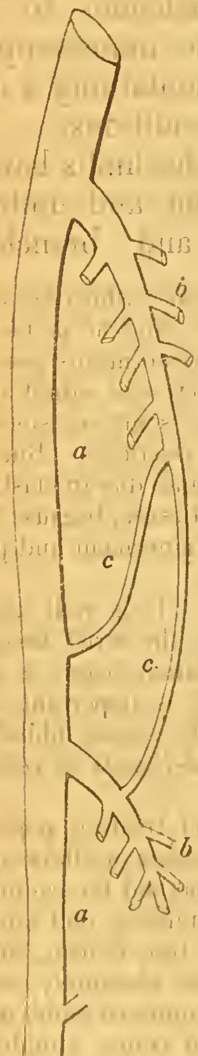

FIG. 9.

Ideal plan of arterial distribution in limbs.

a a, Straight uniform vessels for transmission.

b b, Branching vessels for supply.

c c, Connecting vessels establishing a collateral circuit.

* Mr. Savory, by certain conclusive experiments, proves that the arteries are normally in a state of constant longitudinal tension. He says, "Evidence that this natural condition of the arteries is connected with the ever-varying alterations of extent and direction to which they are subjected in the movements of the body, and that by it their patency and efficiency are secured under every contingency, is fur-

recurrent arteries becoming tributary to the trunks from which they appear to spring, the supply of blood to the parts below is not arrested, although it may be to some extent impeded.* Thus we have an example of the provision made for continuous *supply* analogous to the double system of veins, for securing the uninterrupted *return* of the blood—a provision for maintaining a uniformity of performance under varying conditions.

The plan of arterial distribution in the limbs having been now described as presenting straight and uniform channels for transmission, tortuous and branching

nished by the fact that those arteries are most tense which are most affected by the movement of the part." (p. 10.) And at p. 14 Mr. Savory says, "A state of tension is of course by no means peculiar to the blood-vessels, all the tissues whose pliancy will admit of it are naturally more or less tense; some constantly, some occasionally. In some it is not due to the physical property of elasticity. But the tension characteristic of the vessels is constant, and due to elasticity alone. Moreover, it far exceeds that of all other tissues, because they are tubes whose patency under every condition of movement and position must be maintained."

Mr. Savory, however, adds in a note at p. 12, "It is well known that when the elbow is acutely flexed, the pulse at the wrist becomes imperceptible; and a similar effect upon the circulation below is produced by extreme flexion of the knee. This fact is important, and illustrative of the purpose which the tension of the vessels fulfils."—*On the Shape of Transverse Wounds of the Blood-Vessels in relation to their Physiology.*

* Mr. Ernest Hart has introduced a method of treating popliteal and other aneurisms by simple flexion of the knee-joint or elbow-joint, as the case may require. By Mr. Hart's flexion method the calibre of the arteries at the point of flexure is materially diminished, and this together with the angle at which the flexible arterial tube is bent, effects so considerable a retardation of the current, without absolutely arresting it, as to lead to the deposition of concentric laminated clots, while the pressure of blood on the walls of the sac is of course simultaneously diminished. At least to these circumstances Mr. Hart refers mainly the success of this method of treatment. Thirteen cases of cure have been reported by him and others in the English journals since his first case was brought before the Medico-Chirurgical Society (Vol. xlii., p. 205, of the *Transactions*, 1859). See also *Lancet*, Sept. 3, 1859; Feb. 8, 1862; and the volume of Medico-Chirurgical *Transactions* now forthcoming.

channels for supply, and connecting vessels establishing the collateral circuit, (see Fig. 9,) we have next to inquire what purposes are served by such an arrangement.

Due velocity and temperature, with suitable continuity of supply, appear to be the principal conditions subserved by the peculiar distribution arrangements which have now been passed in review. Of the two former, namely, velocity and temperature, it may be necessary to say a few words.

The straight uniform tubes offer the minimum of resistance, and therefore the blood is as little as possible deprived of its velocity.

The branching and zigzag tubes offer increased resistance, and, in addition, by increasing the area of aggregate section, diminish velocity.

The friction in straight tubes of the dimensions now under consideration is in so small a degree affected by their length, that the portion of the total friction due to this element may be disregarded; in other words, in examining how it comes to pass that the pulse is so nearly synchronous in all arteries, the transegmental trunks may be taken for all practical intents and purposes as having no length; so that each segment may be considered as substantially at the same distance from the heart.

The straight tubes* transmitting the blood to distal parts, with the least loss of original velocity, thereby

* A tortuous state of arteries normally straight, taking into consideration the fact pointed out by Mr. Savory, namely, that of the constant longitudinal tension of blood-vessels, must constitute a symptom of very great importance. It must indicate under certain circumstances an alarming failure of nutrition, and one especially threatening the integrity of the cerebral circulation. A failure of nutrition, acting on the arterial tissues, permits their yielding to the pressure of the blood, and thus the arteries become elongated and necessarily tortuous. A tortuous radial may imply a badly-nourished arterial system—a badly-nourished arterial system implies weakness of cerebral arteries—and weakness of cerebral arteries, a liability to apoplexy and paralysis.

provide against the loss of heat by the blood; and, consequently, maintain the parts most distant from, at a temperature little below that of, those nearest to the heart.

The segmental, branching and diminishing tube, by delaying the blood, allows it to impart its heat to the tissues traversed, and, besides, renders the supply to the capillary system more steady and uniform, and less liable to be interfered with by temporary disturbing causes.

For example, Poiseuille found that the influence of violent respiratory movements was less perceptible in a muscular branch of the crural of a horse than in the carotid.*

It would thus seem that the segmental artery is an apparatus standing between the direct trunk and the capillary system, by which the flow of blood is regulated or equalized in those vessels nearest the capillary system, and that the retardation observed by Physiologists in the capillaries is not suddenly brought about, but anticipated in the segmental arteries.†

To recapitulate, in conclusion, the main trunk divides

* "Nous remarquerons en outre, en nous renfermant dans l'expérience No. 11 que, lorsque de violens efforts respiratoires ont lieu, les différences de hauteurs dues à l'inspiration, et à l'expiration, présentées par le rameau de la crurale, sont à la vérité un peu plus grandes que dans le cas où les mouvemens respiratoires ont lieu dans l'état normal, mais ces hauteurs n'offrent pas les énormes différences que présentèrent les hauteurs donnés dans les mêmes circonstances par l'hémodynamomètre placé sur la carotide."—*Journal de Physiologie*, tome viii., p. 272.

† I laid the foregoing anatomical facts before my colleague, Dr. Burdon Sanderson, knowing him to be engaged in physiological experiments having reference to the circulation of the blood, and he most kindly favoured me with the following note, which he has given me permission to print here:—

"The physiological importance of the fact above stated relating to the anatomical arrangement and distribution of the arteries of the limbs, is derived from the assumption that it is necessary for the maintenance of healthy nutrition that, in all arteries of distribution, the cir-

(Fig. 9) into an artery, for transmission to the distal segment, and another for the nutrition *and warming* of the proximal segment: the transmissive artery is suited to satisfy the hydraulic conditions for the rapid passage of the blood through it, thereby preserving the blood's

culation should be equally rapid whatever the distance of the artery itself, or of the parts supplied by it, from the heart. The truth of this assumption will perhaps hardly be questioned, for the quantity of blood necessary for the nutrition must clearly be the same in all parts of the body, provided that the tissues compared are of the same nature. As regards the arteries of organs differing in structure, it is possible that the principle does not hold good; it may well be supposed that just as the capillary circulation of different tissues exhibits material differences of arrangement, the arteries leading to them may convey blood at very different rates relatively to the area of their sections—that is, at very different velocities. This has not, however, been ascertained by experiment.

"In the preceding pages it has been shewn, as regards the arrangement of the arteries of limbs, that the principal artery, after giving off a large branch near its origin for the supply of adjacent parts, is continued in its original course by an undivided artery destined to convey blood to those which are more remote. The effect of this arrangement on the circulation of the limb may be considered (1), as regards the velocity of the arterial current, and (2), as regards its pressure or tension. With reference to the former, it is well known that (with the exception of the aorta) every artery in dividing is represented by branches, the sum of the calibres of which is greater than that of the trunk, and that the more numerous the branchings the greater the disparity, so that the aggregate area of the arterial system in its ultimate ramifications is enormously greater than that of the aorta. Inasmuch, therefore, as the velocity of a current in any system of branching tubes is equal to the quantity of blood which flows into and out of it, divided by the calibre or the sum of the calibres of the arteries which compose it, it is obvious that in an artery which branches rapidly the loss of velocity must be correspondingly rapid. In an artery which does not branch *at all*, the velocity may either remain stationary, which will be the case if it maintains the same calibre—increase, if it diminish in calibre,—or diminish, if the area of its section increases. As in the 'transegmental' artery of a limb, the area of section is equal throughout, it follows that blood is actually delivered by such an artery with the same velocity as that which the current manifests at its origin.

"The effect of branching, in retarding the arterial current, is well shewn in the experiments of M. Chauveau of Lyons, who has lately

heat; the nutrient artery is arranged so as to delay the blood, to deliver it with diminished velocity to the capillary system, and to allow it to yield part of its heat to the tissues of the segment. The communicating vessels serve to maintain a continuous supply—to secure a uniform result under varying conditions.

succeeded in determining the velocity of the movement of the blood conveyed by arteries with much greater accuracy than had been attained by any previous investigator. He found that while in the carotid, blood was propelled at the rate of about fifty-two centimeters in a second at each contraction of the ventricles, the most rapid movement produced in the facial did not exceed seventeen centimeters in a second. No experiments have as yet been made as to the comparative velocity of the current at the opposite extremities of undivided arteries.

"The *pressure* of the blood-current in the arterial circulation is affected by conditions so numerous and complicated, that it is one of the most difficult problems in animal mechanics to determine their operation with precision. It may, however, be stated generally, that the pressure of the blood in an artery depends (1), on the force with which the blood is transmitted *à tergo* to the artery, and (2), the resistance which is offered to the current of blood by the channels through which it has to pass by its own cohesion. Resistance is offered by the arteries, capillaries, and veins, but in far greater degree by the capillaries than by any other part of the vascular system. In an artery without branches, even though of considerable size, the obstacle to the progress of the blood is so small in proportion to the sum of the resistance offered to the circulation, that the difference between the pressures manifested at its commencement and termination must be so inconsiderable, as not to be of the slightest practical importance."

FINIS.